

Question: What is Biochar?

Answer: A wide range of products obtained through thermal conversion of biomass



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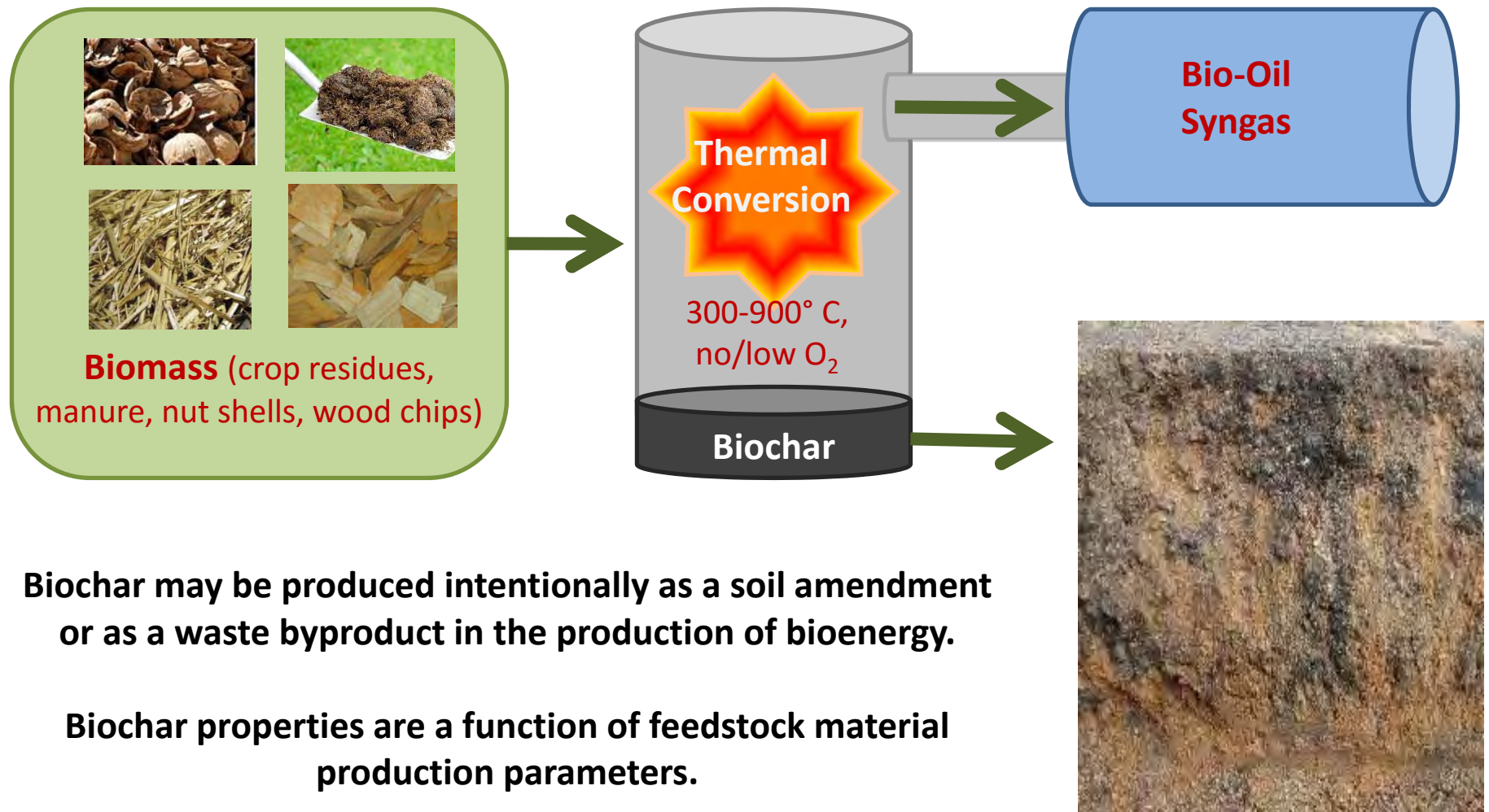
University of California – Davis

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What are Biochars?

Biochars are charcoal products created from thermal conversion biomass in low/no oxygen, and are typically used as a soil amendment.



Biochar may be produced intentionally as a soil amendment or as a waste byproduct in the production of bioenergy.

Biochar properties are a function of feedstock material production parameters.

Why Biochar?

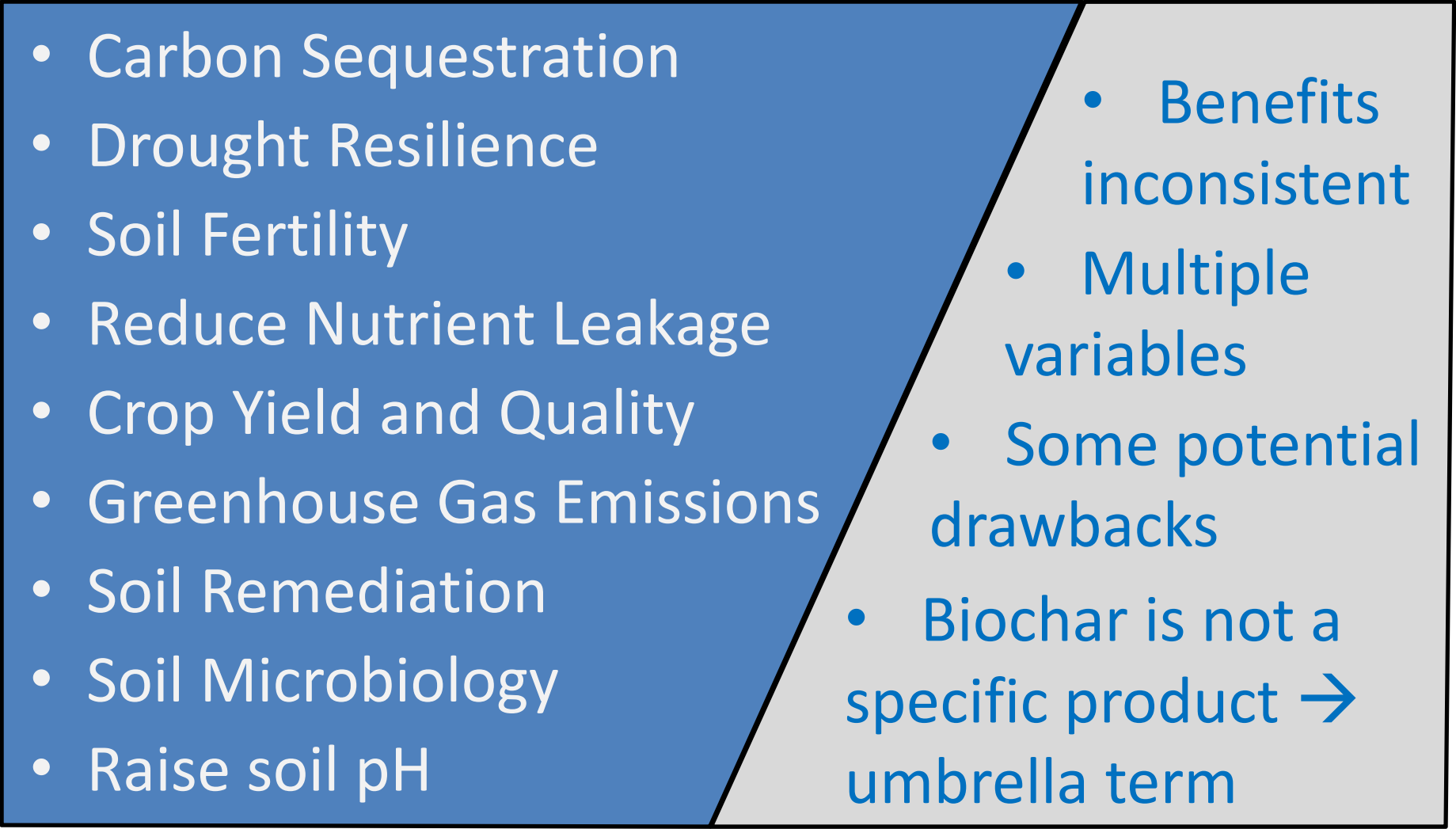
“Terra Preta de Indio” – Amazonian Black Earth

- Brazil and other parts of South America
- 500 to 2500 yrs B.P.
- Addition of charcoal (black carbon/biochar) for soil management
- Today, high organic matter content and more fertile
- Now have a wide range of agricultural and environmental applications



<http://www.biochar-international.org/files/graphics/terra-preta.jpg>

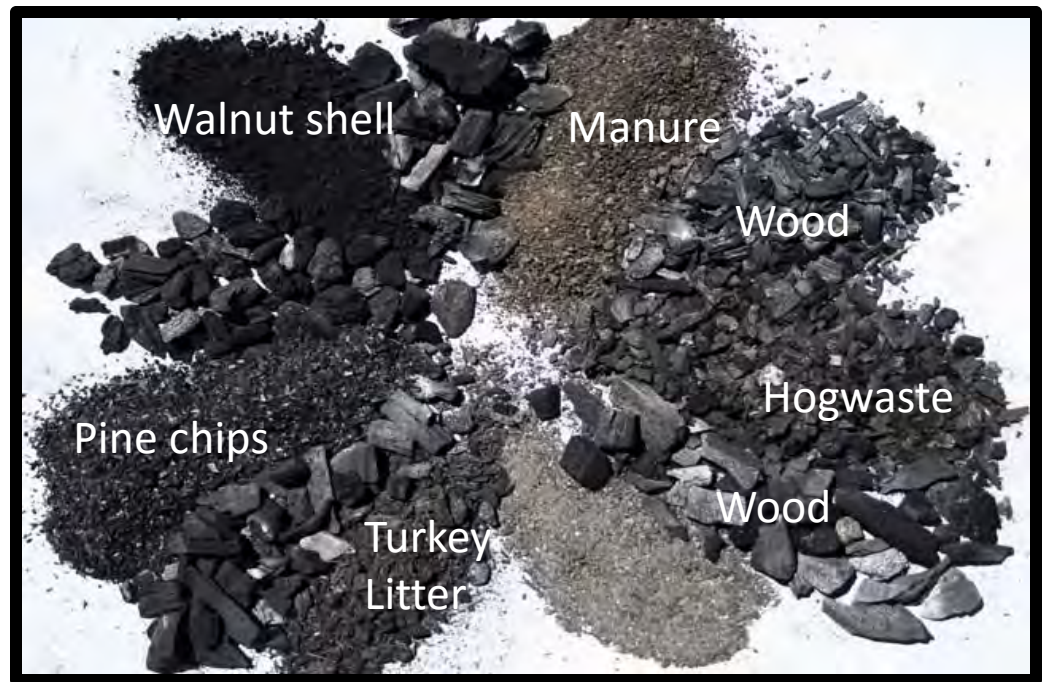
Potential Reasons to Use Biochar in Soil

- 
- Carbon Sequestration
 - Drought Resilience
 - Soil Fertility
 - Reduce Nutrient Leakage
 - Crop Yield and Quality
 - Greenhouse Gas Emissions
 - Soil Remediation
 - Soil Microbiology
 - Raise soil pH
- Benefits inconsistent
 - Multiple variables
 - Some potential drawbacks
 - Biochar is not a specific product → umbrella term

How do biochars differ?

Some Key Characteristics

- pH
 - H/C ratio
 - C/N ratio
 - Porosity
 - Elemental composition
- function of production temperature, production method, residence time, and feedstock
- Surface area
 - Ash content
 - Cation exchange capacity (CEC)
 - Water holding capacity



biochar.ucdavis.edu

UC Davis Biochar Database

biochar.ucdavis.edu

HOME

Welcome to the UC Davis Biochar Database. The database serves as an open-access tool for biochar users, manufacturers, and researchers. This database was initially released on May 1, 2013 and we will continue to work to increase the number of biochars which are included. We hope you see the value in this resource and will contribute and participate in this community centered biochar project.



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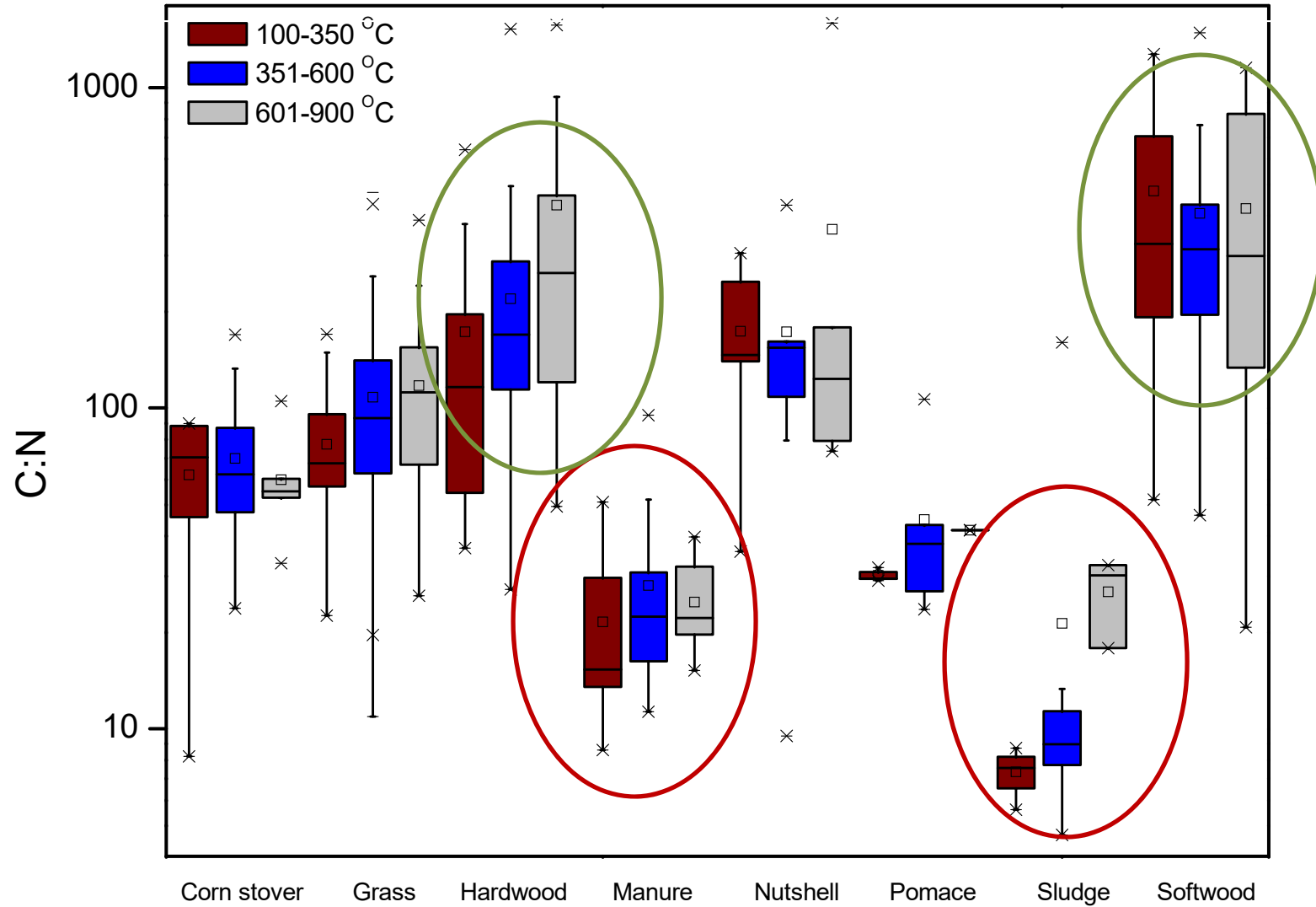
REASON FOR DATABASE

Biochar is charcoal created from pyrolyzed biomass, and differs from charcoal only in the sense that its primary use is not for fuel but rather as a soil amendment.

Biochar research, although still in its infancy, has generated much interest as a soil amendment due to its potential for increased soil fertility, water holding capacity, greenhouse gas reduction and carbon sequestration. The relatively low entry barrier to biochar manufacturing has resulted in many suppliers producing boutique biochars which make use of a variety of feedstock materials. Even with the current public interest in this material, our understanding of how biochar properties impacts the potential benefits is largely inadequate. This deficit in basic biochar science makes it difficult for biochar end users to make informed decisions regarding the specific biochar properties to consider when selecting a particular biochar for their use. The idea for this database arose from this research conducted in the [Pankh Environmental Soil Chemistry Laboratory](#) at University of California, Davis which aimed to determine trends in biochar physical and chemical properties based on feedstock source. The UC Davis Biochar Database was launched as an open-access resource to facilitate bridging this gap.

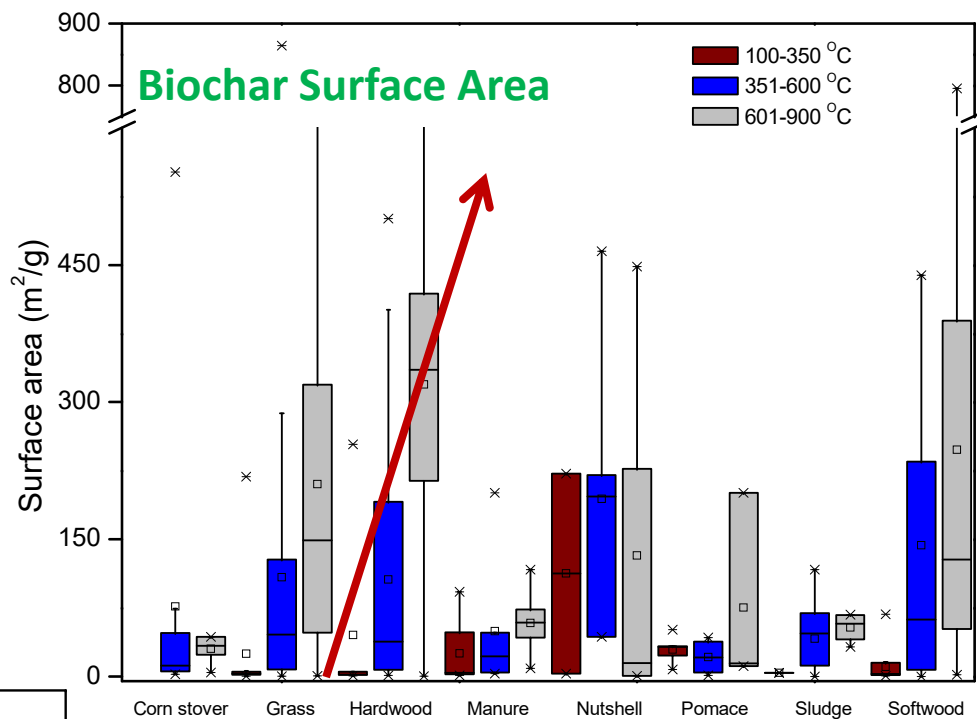
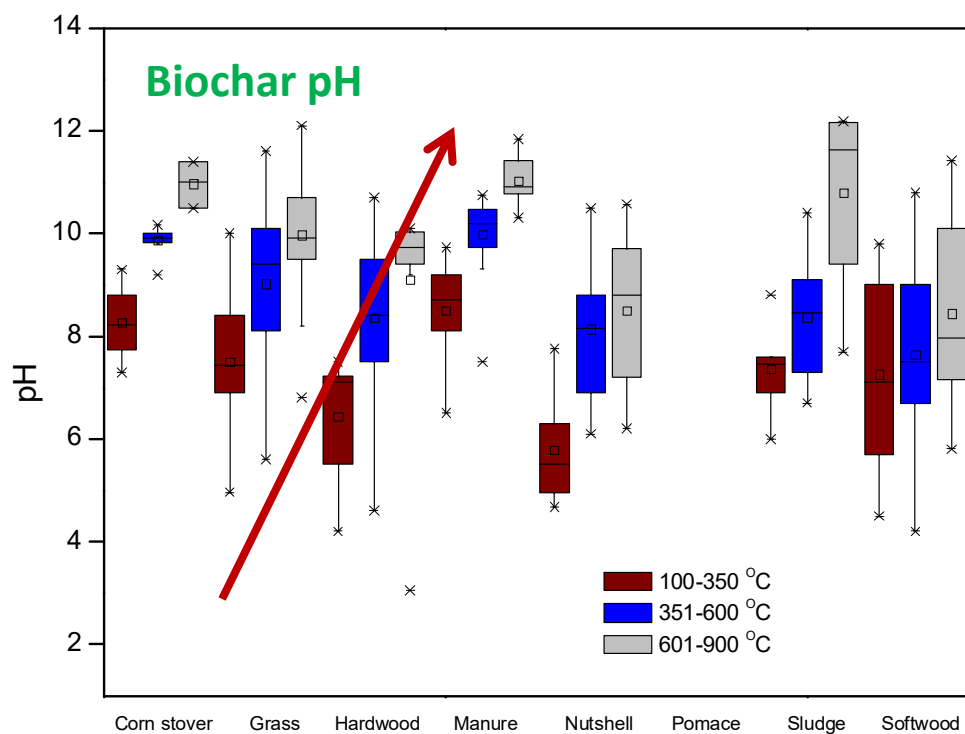
Over 1,150 biochars
in database &
growing

Feedstock Impacts



Data from The UC Davis Biochar Database: biochar.ucdavis.edu

Production Temperature Impacts



Data from The UC Davis Biochar Database:
biochar.ucdavis.edu

Meta-analysis studies

“Biochar is not a single entity but rather spans a wide range of black carbon forms.”

- **50% of studies show yield increases with biochar** (or black carbon)
→ 50% report decreases or no significant decreases
- Agronomic benefits in degraded soils are often emphasized, negligible and negative results not given as much attention.

Biochar does not always provide benefits.

- *We must determine the conditions for biochars, soils, and cropping systems where maximum benefits can be realized for a desired outcome.*

- Range: -28% to +39%

- Greatest benefits:
 - Acidic soils: +14%
 - Neutral soils: +13%
 - Course texture: +10%
 - Medium texture: +13%

Biochar provides benefits when it can impact:

- pH (“liming”), porosity, nutrient availability

Jeffery et al. 2011

Biochar defined in California

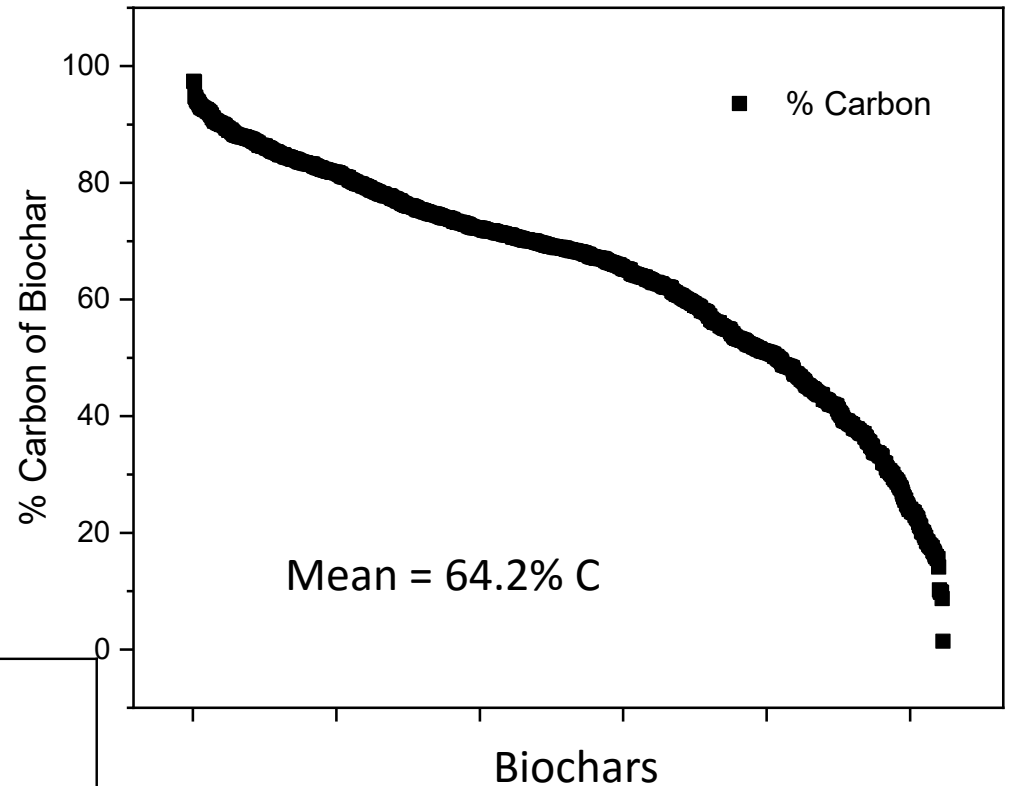
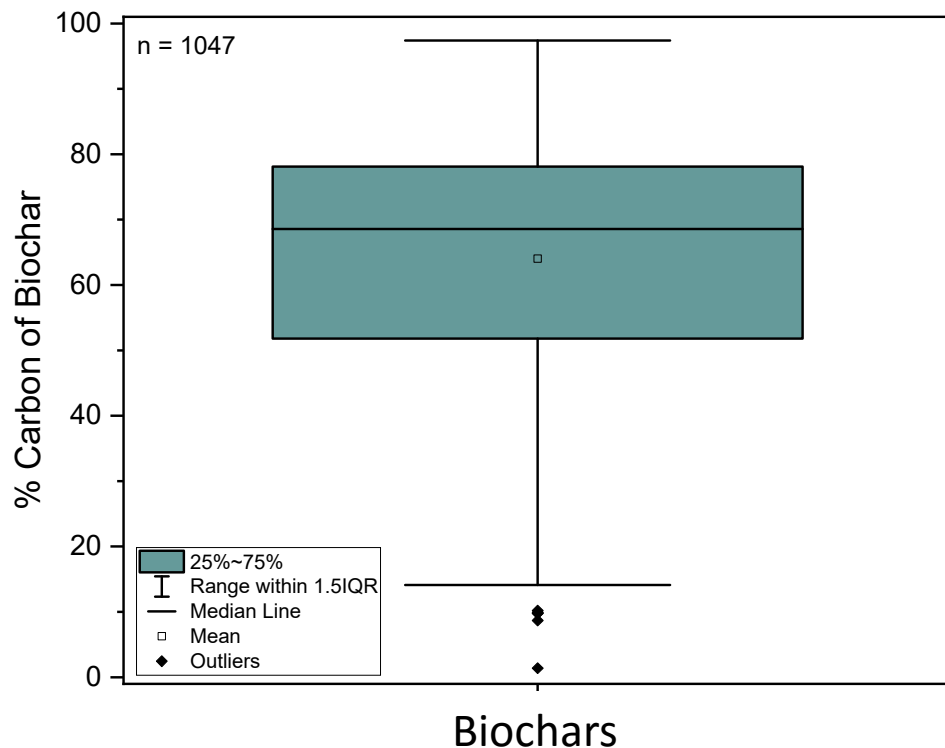
September 25, 2016

Governor Brown signs biochar legislation bill – AB2511

AB 2511: This bill clarifies that “biochar” is a soil amendment that is included in the definition of “auxiliary soil and plant substance” and, therefore, subject to licensing and labeling laws, and defines “biochar” to mean materials derived from thermochemical conversion of biomass in an oxygen-limited environment containing at least 60 percent carbon.

Carbon content of “biochars” can vary greatly

Carb data from 1047 biochars
collected from peer-reviewed
publications.



Most biochars have ~52-78% C

Nearly half of all “biochars” do not
meet the CA definition of biochar.

*Data from The UC Davis Biochar Database:
biochar.ucdavis.edu*

Governor's Office of Planning & Research (OPR)

Biochar Research Advisory Group



Chairs: Sanjai J. Parikh (UC Davis), Amrith Gunasakara (CDFA)

Coordinated with: Michael Maguire (OPR)

Intended Purpose

- Assist the state of California with identifying research gaps in the scientific literature, as they pertain to California specific environmental, economic, and regulatory conditions

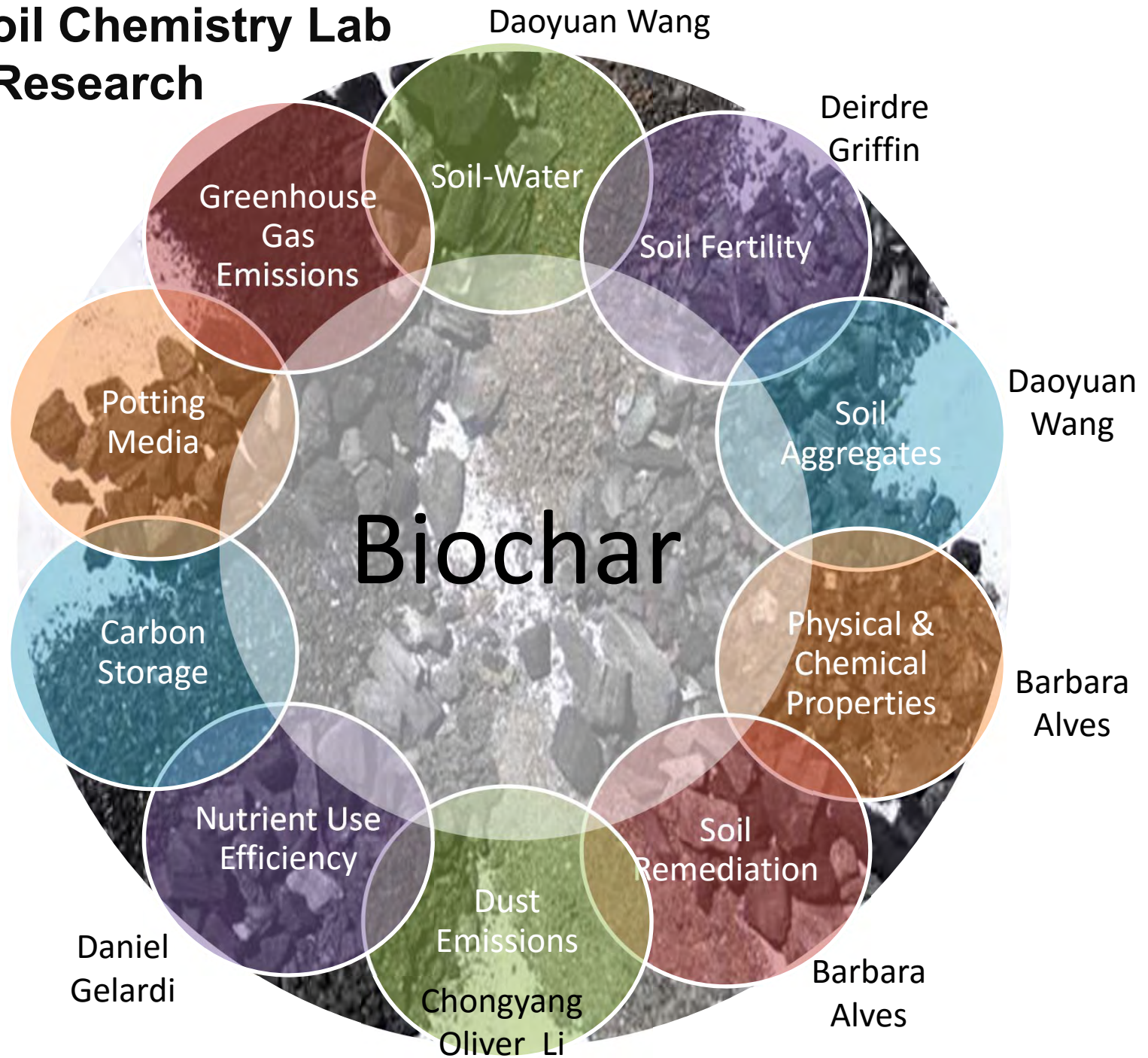
Sanctioned by

Participating state/federal government entities, academic institutions, and non-profits include, but are not limited to:

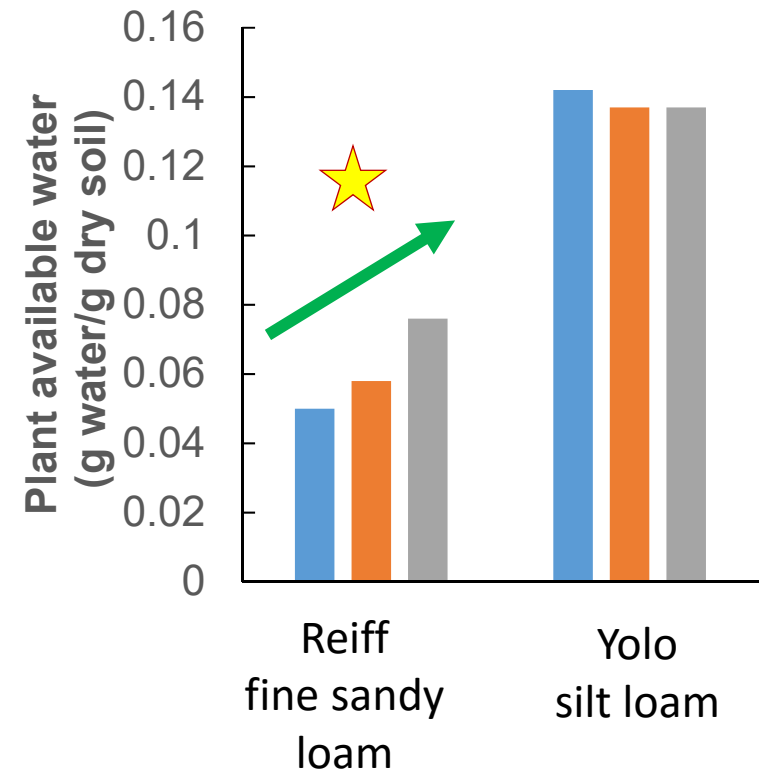
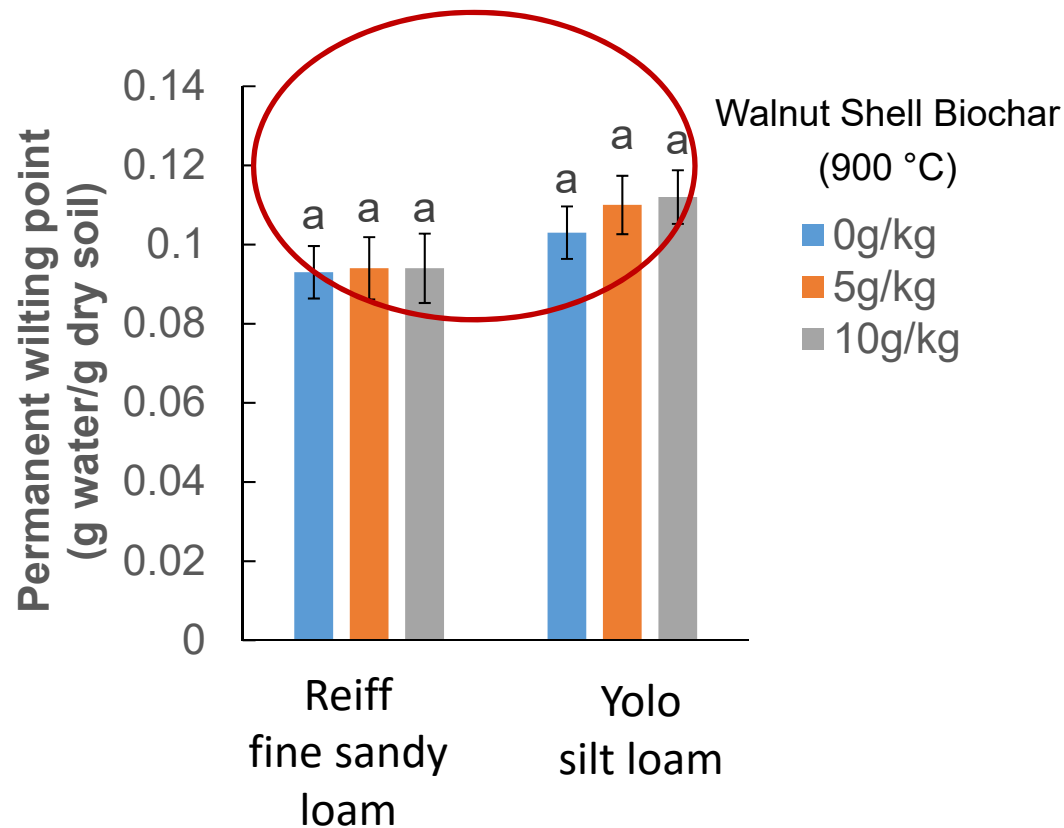
- Governor's Office of Planning and Research (OPR)
- Governor's Office of Business and Economic Development (Go-Biz)
- California Department of Food and Agriculture (CDFA)
- State Water Resources Control Board (SWRCB)
- California Energy Commission (CEC)
- California Natural Resources Agency (CNRA)
- California Department of Forestry and Fire Protection (CAL FIRE)
- Sierra Nevada Conservancy (SNC)
- California Association of Resource Conservation Districts (CARCD)
- California Department of Resources Recycling and Recovery (Cal Recycle)
- Air Resources Board (ARB)
- US Forest Service (USFS)
- University of California (Riverside, Merced, Davis, Cooperative Extension)

Parikh Soil Chemistry Lab

Biochar Research

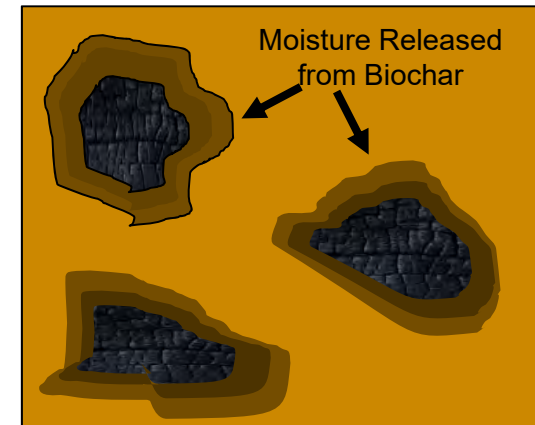
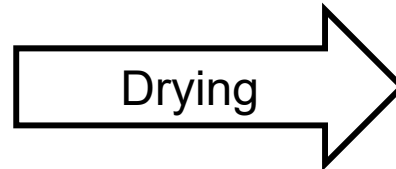
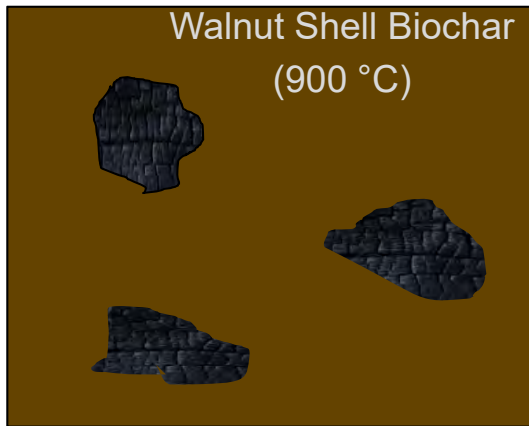


Impact of Biochar on Soil Water

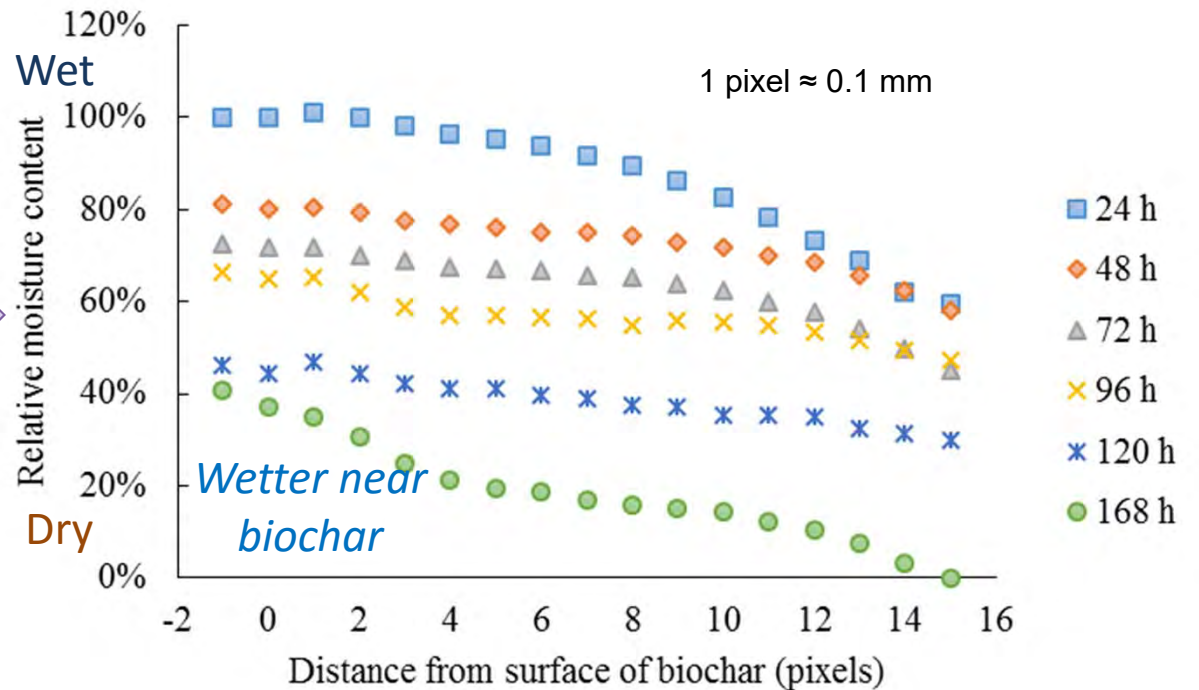
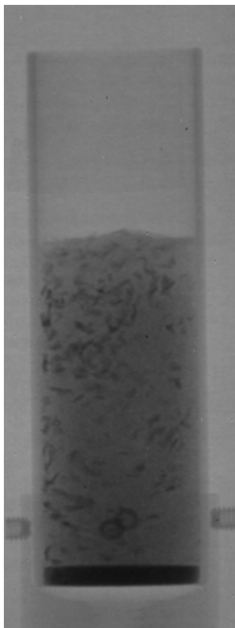


- *Wilting Point: no impact on permanent wilting point in either soil*
- *Plant Available Water: slight increase in the fine sandy loam*

Can water within biochar become available as the bulk soil dries?



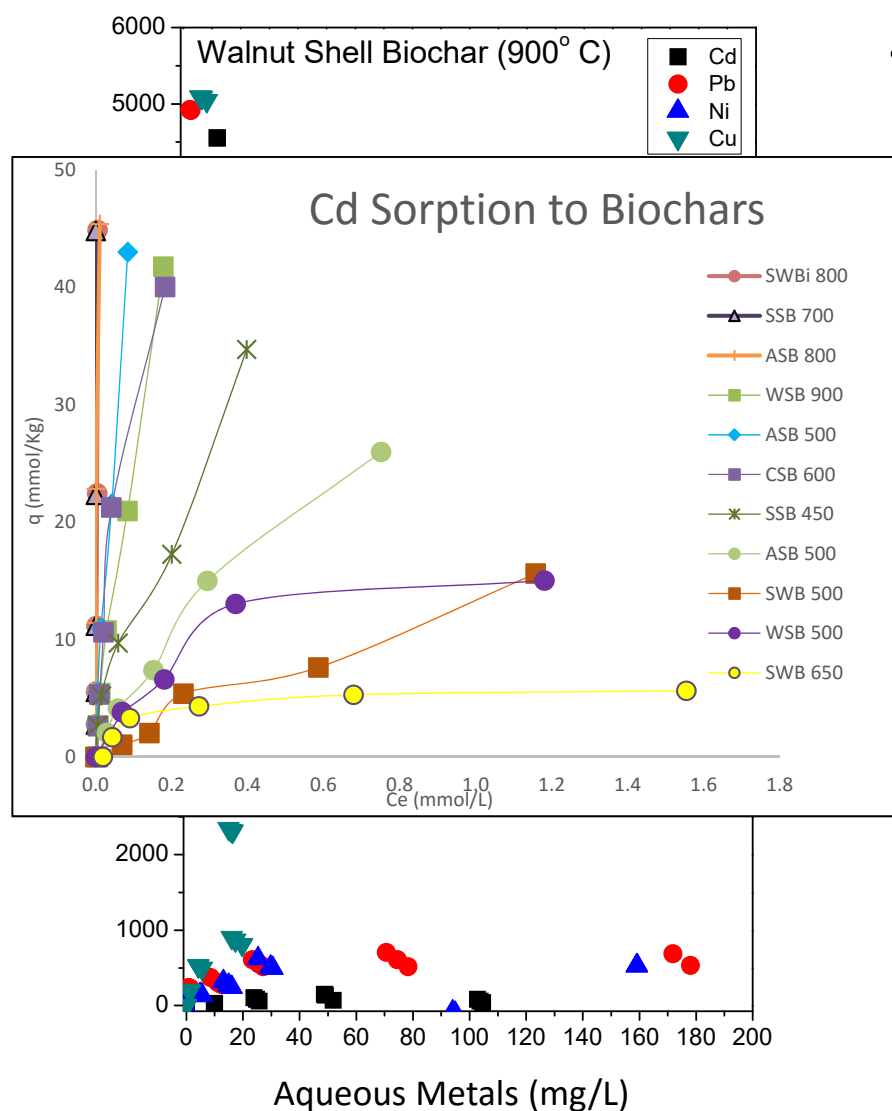
Moisture Distribution Around Biochar with Drying (7 days)



Wang et al., in preparation

Reducing Heavy Metal Bioavailability

- Biochars have differing reactivity
- Walnut shell biochar binds more metals than pine wood biochar

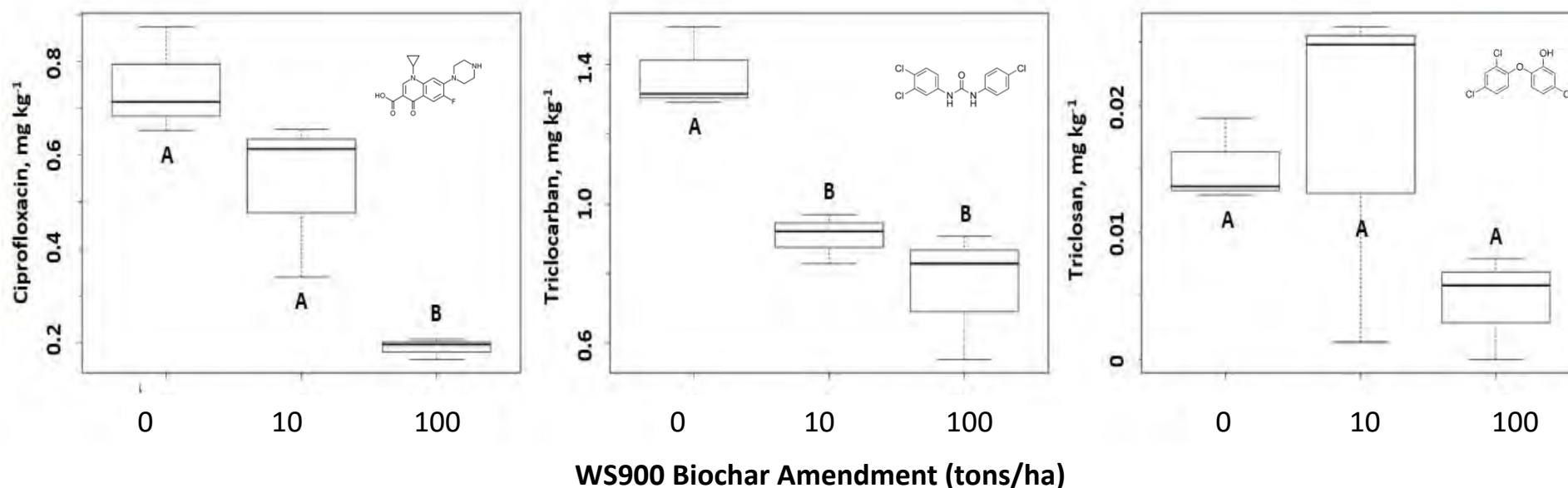


- California's Salinas Valley sits on the Monterey Shale formation and soils are enriched in Cd.
- Spinach is a Cd hyperaccumulator
- Management strategies to reduce Cd uptake are needed
- Currently examining >10 biochars



Plant uptake of pharmaceuticals from biosolid amended soils

- Screening of various biochars (e.g., softwood thermosequence) showed highest binding of selected pharmaceuticals to walnut shell biochar (900 °C)



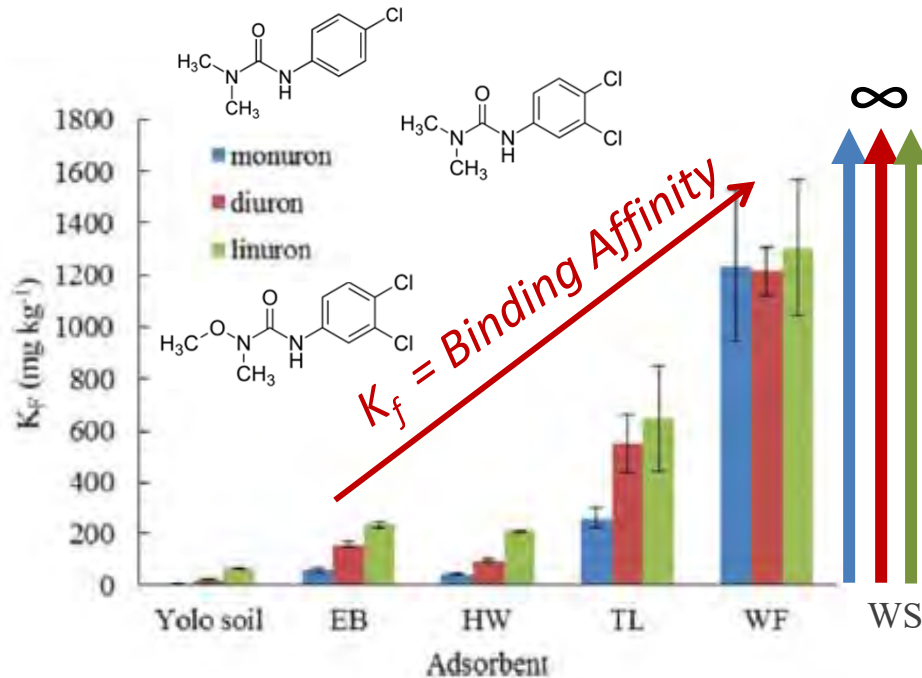
In many cases WS900 biochar reduced the plant uptake and/or translocation of applied pharmaceuticals

- Cipro: reduction in leaves (carrots and lettuce)
- TCC: reduction in leaves (carrots and lettuce) and roots (lettuce)
- TCS: reduction in roots (carrot)



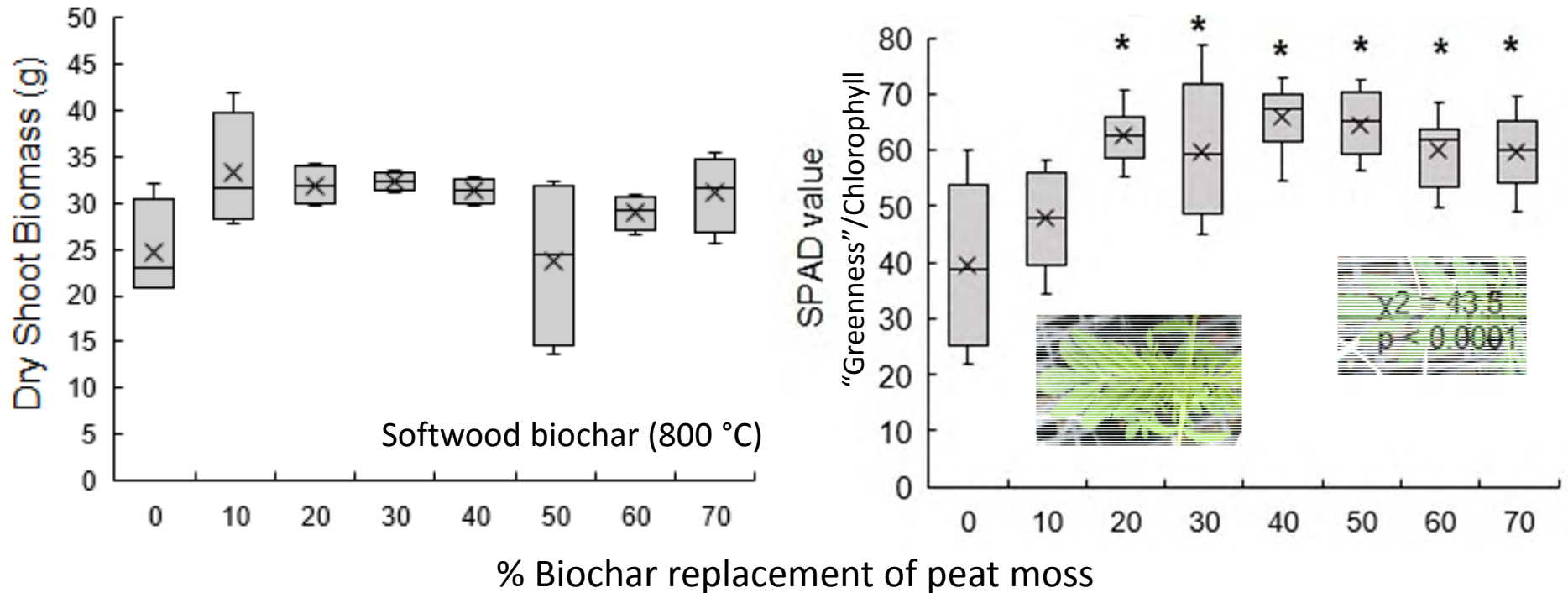
Could Biochar Reduce Pesticide Efficacy?

Freundlich binding constant (K_F)

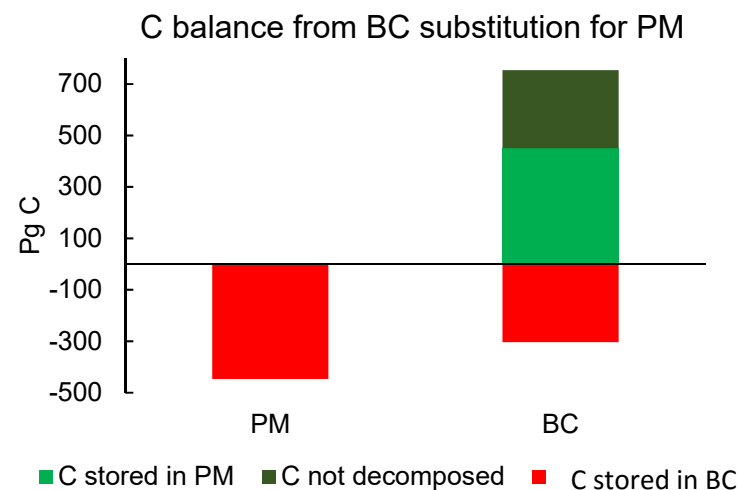


- Varied affinity of herbicides for biochars
- Suggests biochar may reduce the efficacy of soil applied herbicides
- walnut shell biochar binding > soft wood > turkey litter > hog waste > wood/algal digest.

Can Biochar Replace Peat Moss in Potting Media?



In collaboration with Mike Woelk (Corigin) and Josiah Hunt (Pacific Biochar)



Assumptions:

Half-life ($t_{1/2}$):

- PM = 13.5 yr
- BC = 100 yr*

C content:

- PM 50%
- BC 68%
- 450 Pg C in global peatlands
- BC made from wastestream

*conservative estimate

Margenot et al.
Industrial Crops & Products. 2018



Biochars?

- variable product – not all the same or equal
- benefits can be real, but can also be highly variable
- will not *always* provide benefits
- benefits most likely when *optimized* for specific climate-soil-plant-cropping systems, AND an intended outcome
- knowledge base is rapidly growing
- additional information on physical, chemical, and biological *mechanisms* is needed

*Biochars have potential to be part of “the solution”;
a thoughtful, prescriptive, and prudent approach is
most likely to yield consistent benefits*

Acknowledgements

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- Ina Popova, Univ. of Idaho
- Thomas Young, UC Davis
- Peter Green, UC Davis



February 2018. Back row, left to right: Sanjai Parikh, Xiaoming Wan, Shalini Rajput, Natalie McElroy, Andrea Aguilera. Front Row: Barbara Alves, Mary Derting, Daniel Rath, Xiao Ma, Dani Gelardi, Devin Rippner, Chongyang Li. Missing: Deirdre Griffin, Daniel Rath

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